JCS Journal of Chest Surgery
https://doi.org/10.5090/jcs.23.086
pISSN: 2765-1606 eISSN: 2765-1614
J Chest Surg. 2024;57(3):272-280

Check for updates

Clinical Research

The "Weekend Effect" in Extracorporeal Cardiopulmonary Resuscitation

Kinam Shin, M.D.[1,*], Won Chul Cho, M.D., Ph.D.[2,*], Pil Je Kang, M.D.[1]

[1]Department of Thoracic and Cardiovascular Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul; [2]Department of Thoracic and Cardiovascular Surgery, Gangneung Asan Hospital, University of Ulsan College of Medicine, Gangneung, Korea

ARTICLE INFO
Received July 6, 2023
Revised December 23, 2023
Accepted January 2, 2024

Corresponding author
Pil Je Kang
Tel 82-2-3010-3906
Fax 82-2-3010-6966
E-mail kfeelj78@gmail.com
ORCID
https://orcid.org/0000-0002-7587-0911

*These authors contributed equally to this work as first authors.

Background: The phenomenon known as the "weekend effect" impacts various medical disciplines. We compared outcomes between regular hours and off hours to investigate the presence of the weekend effect in extracorporeal cardiopulmonary resuscitation (ECPR).
Methods: Between January 2018 and December 2020, 159 patients at our center were treated with veno-arterial extracorporeal membrane oxygenation (ECMO) for cardiac arrest. We assessed the time required for ECMO preparation, the rate of successful weaning, and the rate of in-hospital mortality. These factors were compared among regular hours ("daytime": weekdays from 7:00 AM–7:00 PM), off hours on weekdays ("nighttime": weekdays from 7:00 PM–7:00 AM), and off hours on weekends and holidays ("weekend": Fridays at 7:00 PM to Mondays at 7:00 AM).
Results: The time from the recognition of cardiac arrest to the arrival of the ECMO team was shortest for the daytime group and longest for those treated over the weekend (daytime, 10.0 minutes; nighttime, 12.5 minutes; weekend, 15.0 minutes; p=0.064). The time from the ECMO team's arrival to ECMO initiation was shortest for the daytime and longest for the nighttime group (daytime, 13.0 minutes; nighttime, 18.5 minutes; weekend, 14.0 minutes; p=0.028). No significant difference was observed in the rate of successful ECMO weaning (daytime, 48.3%; nighttime, 39.5%; weekend, 36.1%; p=0.375).
Conclusion: In situations involving CPR, the time to arrival of the ECMO team was longer during off hours. Furthermore, ECMO insertion required more time at night than during the other periods. These findings warrant specific training in decision-making and emergent ECMO insertion.

Keywords: Weekend effect, Extracorporeal membrane oxygenation, Extracorporeal cardiopulmonary resuscitation

Introduction

The "weekend effect" has been found to be associated with increased mortality rates [1]. Previous research has indicated that patients admitted with cardiovascular symptoms over the weekend experience higher mortality rates than those admitted on weekdays [2]. Additionally, several meta-analyses have reported that this effect is associated with poor outcomes. One analysis revealed that off-hours admissions corresponded to increased risk of mortality for a range of diseases, while another study identified the weekend effect in cases of acute coronary syndrome [3,4]. Furthermore, research has shown that patients admitted to intensive care units (ICUs) over the weekend face higher mortality rates than those admitted during the week [5]. Similarly, the weekend effect has been noted in patients receiving extracorporeal membrane oxygenation (ECMO) support, with prior studies indicating comparatively low survival rates at discharge among patients treated on weekends [6,7]. These findings may be due to decreased supervision and the limited availability of certain procedures on weekend days [2].

Sudden cardiac arrest is associated with high mortality, and cardiopulmonary resuscitation (CPR) is the first-line

Copyright © 2024, The Korean Society for Thoracic and Cardiovascular Surgery
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

therapy [8]. In such emergent situations, extracorporeal CPR (ECPR) represents an essential intervention, demonstrating outcomes in mortality and neurological prognosis that are distinct from those of conventional CPR [9]. Considering that ECPR requires advanced skills and rapid decision-making, the potential influence of the weekend effect on ECPR outcomes must not be overlooked. We hypothesized that by examining the impact of the weekend effect on the ECPR process, weaknesses could be identified and survival rates potentially increased. Thus, the objective of this study was to investigate differences in outcomes and procedure durations based on the timing of ECPR.

Methods

Study design

This retrospective analysis was based on data extracted from medical records and a single-center registry. The study enrolled patients who underwent veno-arterial ECMO insertion due to cardiac arrest at our institution between January 1, 2018, and December 31, 2020. We included ECPR cases that were managed in the general ward (GW), ICU, and emergency room (ER). To reduce potential selection bias, we omitted ECPR events that occurred in the operating and angiocardiography rooms, as physicians often attend to patients in these settings. Participation was limited to individuals between the ages of 19 and 80 years. The analysis encompassed several variables, including the time from cardiac arrest to the arrival of the ECMO team, the interval from ECMO team arrival to ECMO insertion, the duration of ECMO support, ECMO-related complications, the rate of successful weaning from ECMO, in-hospital mortality, and Cerebral Performance Categories Scale (CPCS) scores at the time of discharge. We focused exclusively on complications directly associated with ECMO, such as wound infection, hematoma, or compartment syndrome.

This investigation was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the institutional review board of Asan Medical Center (approval no., 2023-0825; approval date, July 4, 2023). The requirement for informed consent from individual patients was omitted because of the retrospective design of this study.

Definition

The study population was divided into 3 groups based on the timing of ECPR. Specifically, “daytime” referred to the period from 7:00 AM to 7:00 PM on weekdays, “nighttime” encompassed the time from 7:00 PM to 7:00 AM on weekdays excluding Friday nights, and “weekend” represented the time from 7:00 PM on Friday to 7:00 AM on Monday, as well as from 7:00 PM on the eve of a holiday to 7:00 AM on the day following a holiday.

“Arrest to arrival” represented the time from the occurrence of cardiac arrest to the arrival of the ECMO team. “Arrival to ECMO initiation” indicated the period from the arrival of the ECMO team to the initiation of ECMO support. If the cardiac arrest took place outside of the hospital and the patient was transported to the ER, we defined the time of patient arrival as “recognition.” “Recognition to arrival” then represented the time to the arrival of the ECMO team, measured from either in-hospital cardiac arrest or the arrival of a patient who had experienced out-of-hospital cardiac arrest. Similarly, “recognition to ECMO initiation” referred to the time from either an in-hospital cardiac arrest or the arrival of an out-of-hospital cardiac arrest patient to the commencement of ECMO support (Fig. 1).

Successful weaning from ECMO was characterized by patient survival for at least 12 hours following the removal of ECMO without the need for its reapplication. If ECMO was reinstated within the 12-hour window, the subsequent duration of ECMO support was added to the previous period of use. Additionally, we regarded weaning from ECMO in cases of heart transplantation or ventricular assist device (VAD) placement as successful if the patient survived for 12 hours after these interventions.

We classified CPCS scores of 1 and 2 as indicative of good neurological outcomes, while scores of 3, 4, and 5 were considered representative of poor outcomes.

Endpoints

The primary endpoints of the study were in-hospital mortality and successful weaning from ECMO. Secondary endpoints included the rate of complications, the CPCS score at discharge, the duration of ECMO support, and the procedural timeframes, including the period from cardiac arrest to the arrival of the ECMO team and the time from the team’s arrival to the initiation of ECMO.

Moreover, we explored variations in endpoints relative to the timing of ECPR to assess the possibility of a so-called weekend effect. We also examined outcomes according to the locations of CPR administration, to adjust for disparities in basic characteristics of the 3 temporal groups. Finally, we evaluated risk factors linked to mortality, complica-

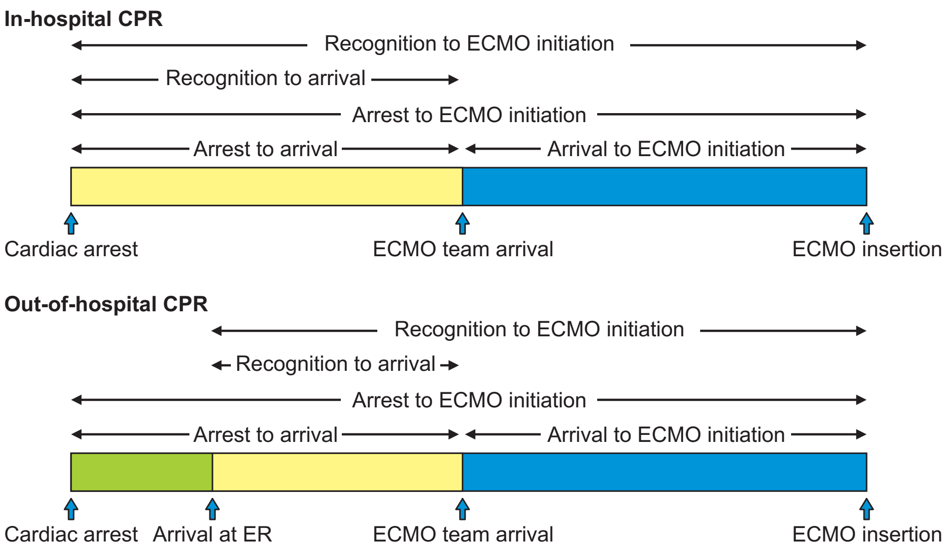

Fig. 1. Definitions of time durations. CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; ER, emergency room.

tions, and failure to wean from ECMO, and we identified additional factors that could impact patient outcomes.

ECPR activation system

In our hospital, a code-blue alarm is activated in response to a CPR event, excluding cases involving patients with registered do-not-resuscitate orders. Should the attending physician opt for ECPR, this decision is communicated to an on-duty resident in the cardiac surgery ICU. The resident then informs the ECMO attending physician, who oversees ECMO cases. Next, a team comprising physicians and perfusionists convenes at the site of the CPR event to initiate ECPR. While a resident and on-duty perfusionist are consistently available within the hospital, the ECMO specialist may not always be on-site. Therefore, during days, nights, and weekends, the responsibility for decisions and the execution of ECMO insertion during CPR falls to the ECMO specialist, clinical fellows, and residents, respectively.

The layout of this hospital includes the ICUs and the ECMO team on the third floor, with the ER on the first floor and the GWs on higher levels. In cases involving ECPR, this layout necessitates that the ECMO team use elevators to reach the GW and ER, while direct ICU access is available without the need for elevator travel. This difference in elevator use may impact the time required to arrive at the CPR site.

Statistical analysis

Categorical variables are presented as numbers and percentages, while continuous variables are expressed as either means with standard deviations for normally distributed data or as medians with interquartile ranges (25th to 75th percentiles) for skewed data. For the comparison of categorical variables across the 3 groups, we employed the Fisher exact test or the chi-square test, depending on the count frequencies. For continuous variables, we first confirmed the normality of the distribution using the Shapiro-Wilk test. We then applied the Bartlett test to assess variance. Based on these results, we selected the most suitable statistical method from the Kruskal-Wallis rank-sum test, analysis of variance (ANOVA), and the Welch ANOVA test. To examine risk factors associated with complications and mortality, we utilized a logistic regression model. A p-value of less than 0.05 was considered to indicate statistical significance, and statistical analysis was performed using R ver. 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics

This study involved a total of 159 patients, with a mean age of 61.0 years. The participants were categorized based on the timing of ECPR, with 60 patients in the daytime group, 38 in the nighttime group, and 61 in the weekend group. The mean patient age was highest in the daytime group and lowest in the weekend group, with mean ages of 65.2 years for daytime, 59.8 years for nighttime, and 57.6 years for the weekend (p=0.032). No significant difference was observed in sex distribution (daytime, 80.0% male;

nighttime, 76.3% male; weekend, 78.7% male; p=0.910). Similarly, no significant differences were noted in height, weight, or body mass index (BMI) (daytime, 24.0 kg/m^2; nighttime, 23.5 kg/m^2; weekend, 24.5 kg/m^2; p=0.847). Cardiogenic shock was identified as the most common cause of CPR, with no significant differences in the causes of CPR among the 3 groups (p=0.768). Pulseless electrical activity was the most frequently encountered initial rhythm, and the distribution of initial rhythms did not differ significantly across groups (p=0.364). Additionally, no statistically significant differences were found regarding the site of CPR administration (Table 1).

Examination of outcomes by ECPR timing

The overall survival rate at discharge was 32.1%, with no statistically significant difference observed among groups (daytime, 21 of 60 patients [35.0%]; nighttime, 11 of 38 [28.9%]; weekend, 19 of 61 [31.1%]; p=0.806). The success rate for weaning from ECMO was 41.5%. Notably, 13 patients were weaned from ECMO following heart transplantation or left VAD placement. While not reaching statistical significance, a tendency toward higher weaning success was observed among those who underwent ECPR during the day (daytime, 29 of 60 patients [48.3%]; nighttime, 15 of 38 [39.5%]; weekend, 22 of 61 [36.1%]; p=0.375). The incidence of ECMO-related complications did not significantly differ across the groups (daytime, 4 of 60 patients [6.7%]; nighttime, 0 of 38 [0.0%]; weekend, 6 of 61 [9.8%]; p=0.154). CPCS scores at discharge also showed no significant variation among groups (Table 2).

The time from arrest to arrival was shortest for the daytime group and longest for those treated over the weekend, although the difference was not statistically significant (daytime, 12.5 minutes; nighttime, 13.0 minutes; weekend, 17.0 minutes; p=0.124) (Fig. 2A). Similarly, the time from recognition to arrival was shortest for the daytime group and longest for the weekend group (daytime, 10.0 minutes; nighttime, 12.5 minutes; weekend, 15.0 minutes; p=0.064) (Fig. 2B). The time from arrival to initiation of ECMO was the shortest for daytime but the longest for nighttime, and this finding was statistically significant (daytime, 13.0 minutes; nighttime, 18.5 minutes; weekend, 14.0 minutes; p=0.028) (Fig. 2C, Table 2).

Table 1. Basic characteristics of patients

Characteristic	Total (n=159)	Daytime (n=60)	Nighttime (n=38)	Weekend (n=61)	p-value
Sex, male	125 (78.6)	48 (80.0)	29 (76.3)	47 (78.7)	0.910
Age (yr)	61.0±14.1	65.2±11.5	59.8±12.2	57.6±16.4	0.032
Height (cm)	166.0±9.8	164.7±9.4	166.7±9.8	166.7±10.3	0.386
Weight (kg)	66.6±16.0	65.5±12.8	65.4±14.9	68.4±19.3	0.877
Body mass index (kg/m^2)	24.0±4.6	24.0±3.8	23.5±4.5	24.5±5.3	0.847
Cause					
Cardiogenic	119 (74.8)	42 (70.0)	29 (76.3)	48 (78.7)	0.768
Ischemic	65	24	15	26	
Heart failure	33	12	8	13	
PTE	6	1	2	3	
Arrhythmia	7	2	2	3	
Others	8	3	2	3	
Respiratory	15 (9.4)	9 (15.0)	3 (7.9)	3 (4.9)	
Hypovolemic	13 (8.2)	5 (8.3)	3 (7.9)	5 (8.2)	
Septic	5 (3.1)	1 (1.7)	2 (5.3)	2 (3.3)	
Unknown	7 (4.4)	3 (5.0)	1 (2.6)	3 (4.9)	
Initial rhythm					0.364
Asystole	43 (27.0)	15 (25.0)	7 (18.4)	21 (34.4)	
PEA	64 (40.3)	27 (45.0)	15 (39.5)	22 (36.1)	
Pulseless VT/VF	52 (32.7)	18 (30.0)	16 (42.1)	18 (29.5)	
Location					0.621
GW	50 (31.4)	21 (35.0)	13 (34.2)	16 (26.2)	
ICU	54 (34.0)	18 (30.0)	15 (39.5)	21 (34.4)	
ER	55 (34.6)	21 (35.0)	10 (26.3)	24 (39.3)	

Values are presented as number (%) or mean±standard deviation.
PTE, pulmonary thromboembolism; PEA, pulseless electrical activity; VT, ventricular tachycardia; VF, ventricular fibrillation; GW, general ward; ICU, intensive care unit; ER, emergency room.

https://doi.org/10.5090/jcs.23.086

Table 2. Clinical outcomes and durations by ECPR timing

Variable	Total (n=159)	Daytime (n=60)	Nighttime (n=38)	Weekend (n=61)	p-value
Survival at discharge	51 (32.1)	21 (35.0)	11 (28.9)	19 (31.1)	0.806
Weaning success	66 (41.5)	29 (48.3)	15 (39.5)	22 (36.1)	0.375
HTPL or VAD	13 (8.2)	6 (10.0)	2 (5.3)	5 (8.2)	0.662
Complications					0.154
None	149 (93.7)	56 (93.3)	38 (100.0)	55 (90.2)	0.421
Wound infection	5 (3.1)	1 (1.7)	0	4 (6.6)	
Hematoma and pseudoaneurysm	3 (1.9)	2 (3.3)	0	1 (1.6)	
Edema	1 (0.6)	1 (1.7)	0	0	
Compartment syndrome	1 (0.6)	0	0	1 (1.6)	
CPCS, good	32 (20.1)	14 (23.3)	6 (15.8)	12 (19.7)	0.658
Arrest to arrival (min)	14.0 (8.0–25.5)	12.5 (6.0–24.3)	13.0 (8.5–16.8)	17.0 (10.0–34.0)	0.124
Recognition to arrival (min)	13.0 (7.0–21.0)	10.0 (6.0–19.0)	12.5 (7.3–16.0)	15.0 (10.0–24.0)	0.064
Arrival to ECMO initiation (min)	15.0 (10.0–21.0)	13.0 (9.0–19.0)	18.5 (15.0–23.0)	14.0 (10.0–21.0)	0.028
Arrest to ECMO initiation (min)	33.0 (23.0–43.0)	31.0 (21.0–38.0)	33.0 (25.5–42.8)	36.0 (24.0–51.0)	0.084
Recognition to ECMO initiation (min)	31.0 (22.0–38.5)	29.0 (17.8–33.5)	33.0 (23.5–40.5)	33.0 (24.0–44.0)	0.030
Duration of ECMO support (min)	3,434 (565–8,895)	4,340 (871–9,314)	2,952 (535–7,410)	3,149 (345–7,012)	0.590

Values are presented as number (%) or median (25th percentile–75th percentile).
ECPR, extracorporeal cardiopulmonary resuscitation; HTPL, heart transplantation; VAD, ventricular assist device; CPCS, Cerebral Performance Category Scale; ECMO, extracorporeal membrane oxygenation.

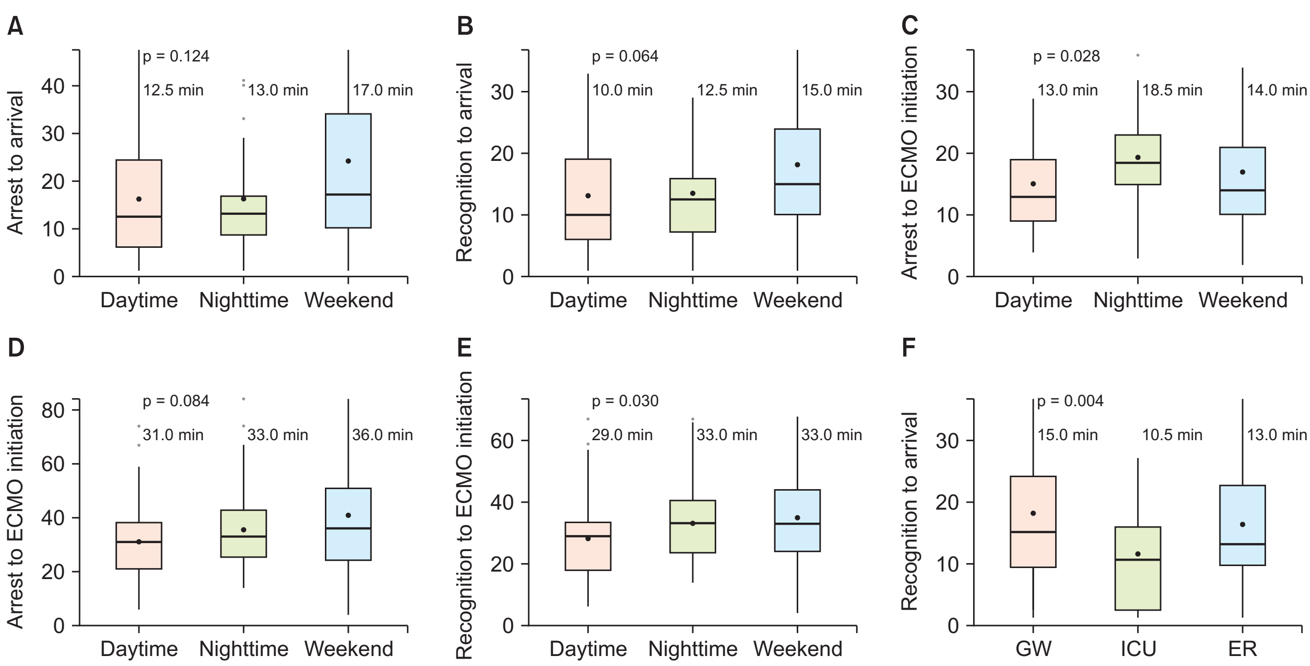

Fig. 2. Comparison of durations between groups. (A) Interval from cardiac arrest to the arrival of the extracorporeal membrane oxygenation (ECMO) team according to extracorporeal cardiopulmonary resuscitation (ECPR) timing. (B) Interval from in-hospital cardiac arrest or the arrival of a patient with out-of-hospital cardiac arrest to the arrival of the ECMO team according to ECPR timing. (C) Interval from the arrival of the ECMO team to the initiation of ECMO according to ECPR timing. (D) Interval from cardiac arrest to initiation of ECMO according to ECPR timing. (E) Interval from in-hospital cardiac arrest or the arrival of a patient with out-of-hospital cardiac arrest to the initiation of ECMO according to ECPR timing. (F) Interval from in-hospital cardiac arrest or the arrival of a patient with out-of-hospital cardiac arrest to the arrival of the ECMO team according to ECPR location. GW, general ward; ICU, intensive care unit; ER, emergency room.

Examination of outcomes by ECPR site

The rates of survival at discharge, successful weaning from ECMO, ECMO-related complications, and CPCS at discharge did not differ significantly across sites. Time from recognition to arrival varied by location, with times recorded as follows: GW, 15.0 minutes; ICU, 10.5 minutes; and ER, 13.0 minutes (p=0.004) (Fig. 2F). However, the time from arrival to ECMO initiation did not significantly differ based on the location of the event (GW, 15.0 minutes; ICU, 16.0 minutes; ER, 13.0 minutes; p=0.526) (Table 3).

Risk factors for mortality at discharge, CPCS score, ECMO failure, and complications

In the univariable analysis, the time from arrest to ECMO initiation was associated with mortality at discharge (odds ratio [OR], 1.03; p=0.021) (Table 4) and with failure to wean from ECMO (OR, 1.02; p=0.020) (Table 4). Although the weekend group appeared to display a higher risk of ECMO weaning failure, this distinction was not statistically significant (OR, 1.66; p=0.173) (Table 4).

Discussion

In this study, we sought to compare outcomes and procedure durations based on the timing of ECPR. Across time periods, the interval from cardiac arrest to the arrival of the ECMO team exhibited a difference of approximately 5 minutes. To account for out-of-hospital CPR, we compared the time from recognition of cardiac arrest to the arrival of the ECMO team. The results indicated that the daytime group experienced the shortest duration, whereas the weekend group encountered the longest, representing a 5-minute difference. Although this difference did not achieve statistical significance, it exhibited a discernible pattern (Table 2). We propose that the extended duration during weekends may be due to a delayed decision-making process, as ECMO specialists are generally not on site at the time. In urgent situations, such as those necessitating CPR, decisions regarding patient care should ideally be made promptly following the initial call for assistance. On-duty residents, who often lack extensive experience, may face challenges in determining whether to initiate ECMO. Furthermore, it is common for the on-call physician, who may not be the patient's original doctor, to be responsible for patient care in various departments. This can contribute to further delays in making key decisions, such as the initiation of ECMO. We believe that these delays could be mitigated by providing residents with targeted training on ECMO indications and by developing protocols for managing emergent situations on weekends.

The interval between ECMO team arrival and the initiation of ECMO was roughly 5 minutes longer for the patients treated at night than for the other groups, suggesting a delay in the insertion of ECMO. This could be attributed to the absence of ECMO specialists during night shifts, as residents or clinical fellows may encounter difficulties when attempting the procedure. We believe that the infrequent exposure to ECPR cases may contribute to such difficulty. Over 3 years, only 159 cases were recorded, representing an average of about 1 ECPR case per week. Considering the resident training curriculum, junior residents likely lack sufficient experience with ECPR cases. Thus, the introduction of a supplementary ECPR training program could decrease the time needed for ECMO insertion during emergency situations. In contrast, while a minor

Table 3. Clinical outcomes and durations by ECPR site

Variable	Total (n=159)	GW (n=50)	ICU (n=54)	ER (n=55)	p-value
Survival at discharge	51 (32.1)	15 (30.0)	17 (31.5)	19 (34.5)	0.877
Weaning success	66 (41.5)	23 (46.0)	21 (38.9)	22 (40.0)	0.734
HTPL or VAD	13 (8.2)	2 (4.0)	8 (14.8)	3 (5.5)	0.124
Complications	10 (6.3)	1 (2.0)	6 (11.1)	3 (5.5)	0.162
CPCS, good	32 (20.1)	10 (20.0)	9 (16.7)	13 (23.6)	0.662
Arrest to arrival (min)	14.0 (8.0–25.5)	15.0 (9.3–24.0)	10.5 (2.3–15.8)	23.0 (10.0–38.5)	<0.001
Recognition to arrival (min)	13.0 (7.0–21.0)	15.0 (9.3–24.0)	10.5 (2.3–15.8)	13.0 (9.5–22.5)	0.004
Arrival to ECMO initiation (min)	15.0 (10.0–21.0)	15.0 (10.3–20.0)	16.0 (9.0–23.0)	13.0 (9.5–20.0)	0.526
Arrest to ECMO initiation (min)	33.0 (23.0–43.0)	33.0 (24.5–44.8)	28.5 (17.0–36.8)	35.0 (25.0–52.0)	0.007
Recognition to ECMO initiation (min)	28.5 (17.0–36.8)	33.0 (24.5–44.8)	28.5 (17.0–36.8)	31.0 (23.0–37.0)	0.116

Values are presented as number (%) or median (25th percentile–75th percentile).
ECPR, extracorporeal cardiopulmonary resuscitation; GW, general ward; ICU, intensive care unit; ER, emergency room; HTPL, heart transplantation; VAD, ventricular assist device; CPCS, Cerebral Performance Category Scale; ECMO, extracorporeal membrane oxygenation.

https://doi.org/10.5090/jcs.23.086

Table 4. Analysis of risk factors for mortality at discharge, poor CPCS, ECMO weaning failure, and complications

Variable	Univariable analysis		Multivariable analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Mortality at discharge				
Age	1.01 (0.99–1.03)	0.375		
BMI	0.96 (0.90–1.04)	0.313		
Arrest to ECMO initiation	1.03 (1.00–1.05)	0.021	1.03 (1.00–1.05)	0.021
Insertion: night	1.32 (0.55–3.18)	0.534		
Insertion: weekend	1.19 (0.56–2.54)	0.653		
Location: ICU	0.93 (0.41–2.15)	0.870		
Location: ER	0.81 (0.36–1.85)	0.619		
Poor CPCS				
Age	1.01 (0.98–1.03)	0.632		
BMI	1.02 (0.93–1.12)	0.663		
Arrest to ECMO on	1.02 (0.99–1.04)	0.170		
Insertion: night	1.62 (0.56–4.67)	0.369		
Insertion: weekend	1.24 (0.52–2.97)	0.624		
Location: ICU	1.25 (0.46–3.38)	0.661		
Location: ER	0.81 (0.32–2.05)	0.653		
ECMO weaning failure				
Age	1.02 (1.00–1.04)	0.093		
BMI	0.98 (0.92–1.05)	0.636		
Arrest to ECMO initiation	1.02 (1.00–1.04)	0.020	1.02 (1.00–1.04)	0.020
Insertion: night	1.43 (0.63–3.27)	0.391		
Insertion: weekend	1.66 (0.80–3.43)	0.173		
Location: ICU	1.34 (0.61–2.92)	0.464		
Location: ER	1.28 (0.59–2.77)	0.535		
Complications				
Age	1.01 (0.96–1.06)	0.704		
BMI	1.00 (0.87–1.15)	0.963		
Arrest to ECMO on	0.98 (0.94–1.02)	0.402		
Insertion: weekend	1.53 (0.41–5.71)	0.523		
Location: ICU	6.12 (0.28–51.79)	0.099		
Location: ER	2.83 (0.28–28.10)	0.375		

CPCS, Cerebral Performance Category Scale; ECMO, extracorporeal membrane oxygenation; OR, odds ratio; CI, confidence interval; BMI, body mass index; ICU, intensive care unit; ER, emergency room.

difference in the time from arrival to ECMO insertion was noted, the deficiency in ECMO insertion seemed to be less evident for the weekend group. This variation may be due to physician fatigue. Given the fluctuating workloads between weekdays and weekends for residents, varying levels of fatigue could influence the proficiency displayed with ECMO insertion.

We examined variations in duration and outcomes of CPR based on the location of its administration. The interval from the arrival of the ECMO team to the commencement of ECMO was comparable across sites, indicating that the ECMO team's performance in initiating ECMO was consistent and efficient. However, we noted a disparity in the time from recognition of the need for ECMO to the team's arrival, with the process being quicker in the ICU than in the GW and ER (Table 3). The layout of the hospital may account for this variation. Since the ECMO team office and the ICU are on the same floor, the response time to this area was reduced. In contrast, reaching the ER and GW may take longer due to the necessity of using an elevator. In light of this hypothesis, the setup time for ECMO could be decreased by either positioning additional equipment in the ER or allocating an elevator exclusively for ECMO team use.

In this study, we observed no statistically significant differences in ECMO-related complications, the success of ECMO weaning, or survival at discharge among the 3 groups. A risk factor analysis revealed that the time from cardiac arrest to ECMO initiation was a risk factor for both mortality and failure to wean from ECMO (Table 4). Another Korean study reported lower survival rates on weekends along with an increase in ECMO-related complications, such as wound infections, bleeding at the cannulation site, and limb ischemia [7]. In contrast, a different study indicated that the interval from CPR to ECMO initiation was a predictor of in-hospital mortality; however, the performance of ECPR on weekends did not emerge as a significant factor in the logistic regression analysis [10]. Thus, the influence of weekends on ECPR outcomes appears to be closely linked to the time elapsed from the arrest to the initiation of ECPR. We propose that various factors, including the ECPR protocol, physician scheduling, variations in experience, hospital infrastructure, and physician fatigue, may impact the time required to perform the ECMO procedure. Extended ischemic time may lead to cumulative damage, which in turn affects outcomes such as mortality and the ability to wean from ECMO.

Previous research on the weekend effect has documented poorer outcomes for myocardial infarction, trauma, and ECPR treated during nights and weekends [5-7,11,12]. A multicenter study found that survival rates from in-hospital cardiac arrests were lower during these off-peak times [13]. Similar findings have been observed in South Korea, with studies examining the weekend effect in ECPR by dividing time into weekdays and weekends [6,7]. In the present study, we instead segmented time into 3 distinct periods. Although both nights and weekends are typically considered off hours, we elected to distinguish between them to account for possible differences in physician fatigue and the availability of in-hospital doctors. This segmentation allowed us to identify specific periods that were more susceptible to the weekend effect and to gain a deeper understanding of this phenomenon. Furthermore, we subdivided the timeline from recognition to the initiation of ECMO into 2 intervals: the time from recognition to hospital arrival and the time from arrival to the commencement of ECMO. This approach helped us determine which stage of ECMO preparation was most vulnerable to the weekend effect.

The present study had several limitations. First, the analysis was retrospective and conducted at a single center, which introduces the inherent constraints associated with retrospective research. Additional studies across multiple centers are necessary to validate our findings. Second, various factors that could affect the prognosis and outcomes of CPR, such as BMI, underlying diseases, and the quality of CPR, were known to be present. However, not every factor could be accounted for in our analysis. Third, the limited number of survivors precluded an exhaustive analysis of complications; future research with larger sample sizes will help address this issue. Lastly, the generalizability of our findings may be limited by differences in hospital structures and notification systems. A multicenter study could provide a more comprehensive evaluation.

In conclusion, in this study, we examined differences in the time required to apply ECMO during ECPR on both nights and weekends compared to daytime periods. Weekends were associated with longer durations from arrest and recognition to the arrival of the ECMO team. In contrast, during nighttime hours, a prolonged interval was noted from the ECMO team's arrival to the insertion of ECMO. Additionally, the time from arrest to initiation of ECMO, which was identified as a risk factor, was longest on weekends. Although neither weekend nor nighttime ECPR was statistically determined to be a risk factor for mortality or success in weaning from ECMO, the observed delays during off hours suggest a potential impact on ECPR outcomes. To improve ECPR results, we recommend the implementation of protocols for early decision-making and the optimization of clinical pathways.

Article information

ORCID

Kinam Shin: https://orcid.org/0009-0003-2098-1205
Won Chul Cho: https://orcid.org/0000-0002-3858-6516
Pil Je Kang: https://orcid.org/0000-0002-7587-0911

Author contributions

Conceptualization: PJK. Data curation: KS. Formal analysis: PJK, KS. Funding acquisition: none. Investigation: PJK, WCC, KS. Methodology: PJK. Project administration: PJK. Visualization: PJK, KS. Writing–original draft: KS. Writing–review & editing: PJK, WCC, KS. Final approval of the manuscript: all authors.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Funding

This work was supported by grant from the Korean Association of Mechanical Life Support (KAMEL 2024-001).

References

1. Honeyford K, Cecil E, Lo M, Bottle A, Aylin P. The weekend effect: does hospital mortality differ by day of the week?: a systematic review and meta-analysis. BMC Health Serv Res 2018;18:870. https://doi.org/10.1186/s12913-018-3688-3
2. Cram P, Hillis SL, Barnett M, Rosenthal GE. Effects of weekend admission and hospital teaching status on in-hospital mortality. Am J Med 2004;117:151-7. https://doi.org/10.1016/j.amjmed.2004.02.035
3. Zhou Y, Li W, Herath C, et al. Off-hour admission and mortality risk for 28 specific diseases: a systematic review and meta-analysis of 251 cohorts. J Am Heart Assoc 2016;5:e003102. https://doi.org/10.1161/JAHA.115.003102
4. Kwok CS, Al-Dokheal M, Aldaham S, et al. Weekend effect in acute coronary syndrome: a meta-analysis of observational studies. Eur Heart J Acute Cardiovasc Care 2019;8:432-42. https://doi.org/10.1177/2048872618762634
5. Galloway M, Hegarty A, McGill S, Arulkumaran N, Brett SJ, Harrison D. The effect of ICU out-of-hours admission on mortality: a systematic review and meta-analysis. Crit Care Med 2018;46:290-9. https://doi.org/10.1097/CCM.0000000000002837
6. Cho HW, Song IA, Oh TK. Weekend effect in extracorporeal membrane oxygenation therapy initiation: a nationwide cohort study in South Korea. Ann Transl Med 2021;9:742. https://doi.org/10.21037/atm-21-180
7. Lee DS, Chung CR, Jeon K, et al. Survival after extracorporeal cardiopulmonary resuscitation on weekends in comparison with weekdays. Ann Thorac Surg 2016;101:133-40. https://doi.org/10.1016/j.athoracsur.2015.06.077
8. Ambinder DI, Oberdier MT, Miklin DJ, Halperin HR. CPR and ECMO: the next frontier. Rambam Maimonides Med J 2020;11:e0013. https://doi.org/10.5041/RMMJ.10399
9. Low CJW, Ramanathan K, Ling RR, et al. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with cardiac arrest: a comparative meta-analysis and trial sequential analysis. Lancet Respir Med 2023;11:883-93. https://doi.org/10.1016/S2213-2600(23)00137-6
10. Lunz D, Camboni D, Philipp A, et al. The 'Weekend Effect' in adult patients who receive extracorporeal cardiopulmonary resuscitation after in- and out-of-hospital cardiac arrest. Resusc Plus 2020;4:100044. https://doi.org/10.1016/j.resplu.2020.100044
11. Carr BG, Reilly PM, Schwab CW, Branas CC, Geiger J, Wiebe DJ. Weekend and night outcomes in a statewide trauma system. Arch Surg 2011;146:810-7. https://doi.org/10.1001/archsurg.2011.60
12. Kostis WJ, Demissie K, Marcella SW, et al. Weekend versus weekday admission and mortality from myocardial infarction. N Engl J Med 2007;356:1099-109. https://doi.org/10.1056/NEJMoa063355
13. Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. JAMA 2008;299:785-92. https://doi.org/10.1001/jama.299.7.785